The Hubble Space Telescope Advanced Camera for Surveys: Post-Servicing Mission 4

AUTHORS: Edward Cheng [1], Marco Sirianni [2,10], Jennifer Mack [2], Stephen Rinehart [3], Kevin Boyce [3], Rebecca Emerle [4], Mark Turczyn [3], Augustyn Waczynski [5], Yiting Wen [6], Ireneusz Orlowski [7], Gregg Waligroski [4], Larry Trubell [4], Ken Albin [4], Markus Loose [8], Raphael Ricardo [8], Hsiao Smith [3], Peter Alea [9], Tracy Meyer [7], John Auyeung [8]

[1]Conceptual Analytics, [2]STScI, [3]NASA/GSFC, [4]Ball Aerospace, [5]GST, [6]MEI, [7]J&T, [8]Teledyne Imaging Sensors, [9]ATK, [10]ESA

Abstract:

Prior to 2007, the Advanced Camera for Surveys (ACS) was the workhorse instrument on the Hubble Space Telescope, accounting for over 70% of scheduled programs. ACS suffered two anomalies in 2006, leading to a switch to the redundant set of electronics. This restored operation of all three channels on the instrument: the Wide Field Channel (WFC), the High Resolution Channel (HRC), and the Solar Blind Channel (SBC).

On January 27, 2007, the instrument was rendered inoperable as a result of a failure of these redundant electronics. The Solar Blind Channel alone could be reactivated using the primary set of electronics.This was completed on February 20, 2007.

Almost immediately after the January 2007 anomaly, the HST Project assembled a team to examine the options for the repair. In a remarkably short time, the instrument condition was assessed, a repair concept developed, and implementation began for a system that will be deployed during Servicing Mission 4 (SM4) in August 2008.

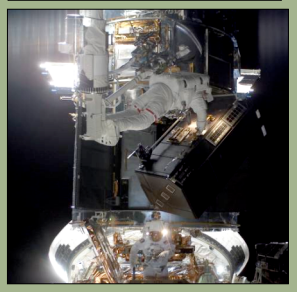
The repair will replace the existing WFC CCD Electronics Box (CEB) and power it using a replacement Low Voltage Power Supply (LVPS). While the highest priority is restoring WFC, the repair hardware also provides the possibility of restoring the HRC by supplying power to the HRC from the new LVPS using the original power bus.

If successful, the repair will restore all three cameras to full operation after SM4, making them available for the Cycle 17 Call for Proposals.

Introduction:

- Installed during SM3B in March 2002, replacing the FOC in axial instrument bay 3
- Powerful 3rd generation HST imager, covering UV/visible wavelengths (115-1050 nm)
- PI: Dr. Holland Ford/Johns Hopkins University
- Prime Contractor: Ball Aerospace
- Three imaging channels:
  - **Wide Field Channel (WFC) :**
    HST's most sensitive, largest field-of-view (FOV) visible/near-infrared imager
    350-1000 nm; 202x202" FOV with 0.050" pixels
    13 broad and narrowband filters, plus polarizers and long-wavelength grism
  - **High Resolution Channel (HRC) :**
    HST's highest spatial resolution and near-ultraviolet (NUV) sensitivity
    200-1000 nm; 29x26" FOV with 0.027" pixels
    17 broad and narrowband filters, plus ramps, polarizers, and coronograph
  - **Solar Blind Channel (SBC) :**
    HST's most sensitive ultraviolet (UV) photon-counting detector
    115-180 nm; 35x31" FOV with 0.031" pixels
    6 filters, 2 prisms (spectroscopic capability)

ACS Installation During SM3B



ACS Failure:

ACS Side-1 failed on June 19, 2006

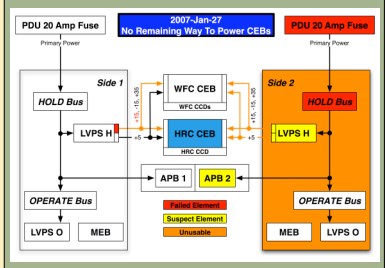
- The loss of the +15V CEB power rail, which supplied power to both the WFC and HRC CEBs, precluded all CCD imaging.
- Probable candidates for the failure:
  1. Interpoint Converter on LVPS3 board in MEB1
  2. Short to ground in the transformer T6 on LVPS3
- Operations with the Side-2 electronics began on July 4, 2006.

ACS Side-2 failed on January 27, 2007

- The short is in the Hold Bus and is due to damage to the LVPS or APB.
- Side-2 is now completely inoperable.
- The Side-2 LVPS is inaccessible to the astronauts for repair and is not part of the repair mission.

ACS was configured for Side-1 operations using the SBC-only on February 15, 2007

Failed State



PDU= Power Distribution Unit,
CEB= CCD Electronics Box,
LVPS=Low Voltage Power Supply,
APB= Auxillary Power Box,
MEB=Main Electronics Box

ACS Repair:

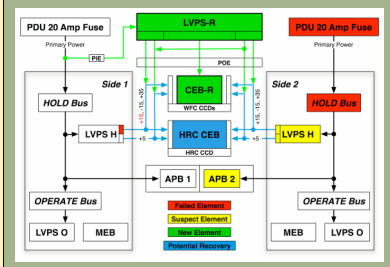
The ACS repair concept replaces the CCD electronics box (CEB) in the WFC. The replacement CEB will be powered by a replacement LVPS that is completely independent of the failed unit.

The replacement CEB will communicate with the WFC CCD, as well as with the rest of the instrument for command and data, via the edge connectors in the original CEB.

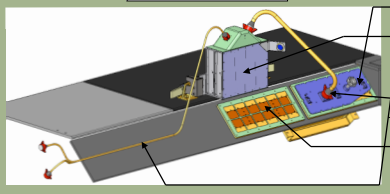
The replacement LVPS draws power from the ACS primary power connectors, accessed via a splitter cable installed by the astronauts.

While the highest priority is restoring the WFC, the ACS repair concept also provides a path for restoring the High Resolution Channel (HRC). In this scenario, the repaired LVPS would provide power to the original power bus, accessed at the WFC CEB. The HRC CEB is wired in parallel with this power bus, which means that, in principle, it could be powered up and operated with power from the new LVPS. There is some risk that the fault(s) in the LVPS shorted the power harnesses, which would defeat restoring the HRC.

Restored State



ACS-Repair Concept



1.) Replace the four WFC CEB boards with a new CEB-R module.

2.) Attach a new LVPS-R to the outside of ACS.
- Connect to ACS input power connector for power.
- Connect to CEB-R.

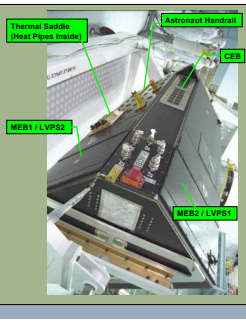
3.) Operate the WFC CCDs with the new CEB-R.
- Power from the new LVPS-R power source.

4.) Use the existing instrument power harness to attempt restoring the HRC CCD by powering the existing HRC CEB from the the new LVPS-R.
- Independent power sources are used so that a failure to "back-power" will not affect the WFC operation.

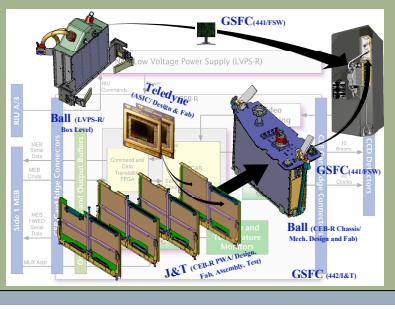
ACS and the Future of HST observing:

- ACS offers powerful, unique imaging capabilities, including:
  HST's largest field of view, highest spatial resolution, and highest sensitivity at UV/visible wavelengths
- Since its installation in 2002, ACS has been the dominant instrument on the observatory in terms of submitted proposals and approved orbits. It will likely remain in high demand following the repair in 2008.
- The ACS-Repair restores unique capabilities not duplicated by WFC3.
- After SM4, ACS will be the only instrument offering coronography and polarimetry.
- ACS will be extremely valuable when used for parallel observing, for example with:
  Large mosaics, with ACS covering the visible and WFC3 the near-UV or infrared
  Deep field observations, with ACS providing wide-field imaging and COS/STIS providing spectroscopic redshifts
- If WFC3 were to fail, a repaired ACS would be the only means of maintaining high-efficiency UV/visible imaging, a crucial capability of the observatory.

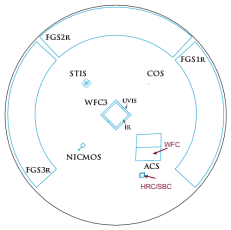
ACS External Features and Access Panel Locations



Key Products/ Responsibilities



The HST focal-plane following a successful SM4



HST Total System Throughputs